A UHF RFID Printed Circuit Board Solution

Murata's MAGICSTRAP®

Production tracking, asset tracking, service tracking and counterfeiting prevention at the PCB level.

Background

Radio Frequency Identification (RFID) technology continues to gain ground in manufacturing, retail, healthcare, pharmaceutical, transportation, defense and packaging industries for asset tracking. The non line-of-sight tag reading, item level identification, re-programmable memory and its anti-counterfeiting security function makes it an attractive solution throughout the supply chain management.

Within the electronics industry, UHF RFID label tags are commonly applied to a piece of equipment once assembly is complete. A new approach allows implementation of the RFID tag directly on the printed circuit board (PCB) early in the production process.

From the manufacturers' perspective, implementation of a PCB RFID tag can provide management with tracking information as specific as the individual printed circuit board to better identify where the product is, where this product is stored and detect bottlenecks within the manufacturing process. A properly executed RFID system can greatly improve efficiencies, control costs and streamline overall production processes. Additional benefits of applying the RFID tag at the PCB level is to assist in inventory control, aftermarket service, warrantee returns and counterfeiting prevention.

Early trials of deploying RFID tracking on PCBs revealed many challenges. Murata addresses these challenges by offering a small RFID module package, named MAGICSTRAP®, that integrates both the RFID tag IC and broadband RF matching functions. The MAGICSTRAP® can be handled using standard pick and place equipment and offers a non-conductive attachment option.

Perspective

Electronic manufacturers are under constant pressure to improve production through put, while managing inventory and quality systems. Knowing the status and location of each sub-assembly, final assembly along with finished goods, can minimize duplicate purchasing, part shortages, inventory outages and excessive inventories.

Manufacturers are looking for a RFID tracking method that provides the following solutions:

- Item level tracking
- Capable of implementing at the start of the PCB assembly
- Functional at the start of the PCB assembly
- Implementation of RFID should not represent a bottleneck
- Compatible with current information systems
- Provides privacy and security protection
- Implementation cost should be low enough to provide positive return on investment
- Easy to modify for different assemblies and production lines
- Capable of withstanding electro static discharge (ESD)
- Functional within finished goods
- Compatible across all industries for supply chain management

Barcode vs. RFID

Barcodes have been widely used for tracking purposes over the past two decades. However, with the trends of global production, the emergence of large offshore contract manufacturers and highly customized products, barcode tracking is starting to show its limitations.

One-dimensional barcode labels can only store a very limited amount of information (a dozen characters) relative to its physical size. Two-dimensional barcodes can store more information (they take more space), but require expensive scanning equipment and accurate optical alignment between the label and scanner. This can decrease the automatic tracking functionality along with increasing the setup time needed when switching from one assemble to another.

Since barcodes are read only, information cannot be modified or customized within the manufacturing process. A new barcode label would have to be added or replaced which adds overhead and may cause the loss of some historical information.

On the other side of the equation, RFID utilizes radio frequency technology. The RFID tag includes an antenna and semiconductor chip that has built in re-writable memory. The main features of the PCB mounted RFID tag include non line-of-sight reading, item level identification and re-programmable memory addressing the weakness of today's barcode, making it a perfect fit for future tracking applications.

Among different variations of RFID technologies, EPC Global Ultra High Frequency (UHF) Gen2 tag is defined for low cost tracking and supply chain management. The

passive EPC Global Gen2 tag operates in the 850MHz-960MHz UHF band. It requires a smaller size of antenna than the Low Frequency (LF) or High Frequency (HF) RFID tag does.

Read distance of UHF RFID technology ranges from .5 to 8 meters depending on the antenna design, reader setting and surrounding environment. EPC Gen2 readers can reliably read up to 100 tags per second even in a noisy environment to accommodate high speed production lines. Each EPC Gen2 tag contains a product EPC ID in addition to a unique Tag ID (TID) that is used to store the IC manufacturers' specific information. Depending on the IC's memory size (up to 1024bits), product information, customer information, revisions levels and authentication are other examples of information that can be stored.

RFID also offers a highly secure identification method to address counterfeiting issues. The TID is fixed at the IC level utilizing a probe method and is locked in before the wafers leave the factory. Combined with the product specific EPC ID, duplication is extremely difficult.

Challenges

From early printed circuit board UHF RFID trials, some of the following challenges were identified:

1) RFID package / placement accuracy
   RFID tag IC's are too small (less than 1mm x 1mm) to be handled by many manufacturing companies and therefore not able to control the placement accurately.
2) Broadband frequency matching
   In typical RFID assemblies, there is no RF matching function between antenna and IC. The lack of the impedance matching makes it difficult for the tag to operate in the full range from the 850MHz to 960MHz.
3) Flexibility of design
   Typically an antenna design is characterized for both the IC and the PCB, therefore switching to a new IC would mean a new antenna design. This can be an issue for large contract manufacturers who serve dozens of OEM customers. A flexible single solution regardless of IC or antenna design would minimize multiple designs and implementation time.
4) Readability of finished product
   As in many electronic products, PCBs are frequently mounted in a shielded metal chassis. This often leaves the tag unreadable from the finished product.

Solution: Murata's MAGICSTRAP®

MAGICSTRAP® is essentially an integrated RFID tag module. It contains an embedded EPC Global UHF Gen2 IC with matching functions designed in the low temperature co-fired ceramic and resin substrate. By providing the RF matching internally, MAGICSTRAP® optimizes the power transfer between the IC and the customer antenna. This allows for multiple-sourced ICs using the same customer's antenna pattern with a footprint compatible package.

Figure 1 Murata MAGICSTRAP®

	MAGICSTRAP®	Flip Chip	JEDEC Strap	TSOP/TSSOP
Package	**Taping**	Wafer	Roll	Taping
Size (mm)	**3.2x1.6x0.55**	5.0x5.0x0.15	9.0x4.0x0.3	4.5x4.0x0.5
Attachment Method	**SMT (Soldering /Adhesive)**	FCB	NCP, ACP	SMT (Soldering)
Z Matching	**Yes (Integrated)**	No	No	No
Required Placement Accuracy	**± 800um**	± 30um	± 800um	± 300um

Table 1 RFID Package Comparison

Attachment Options

Different from traditional RFID IC packages that are required to be soldered to the PCB to make an electrical connection, MAGICSTRAP® can be adhered to the PCB using either a non-conductive epoxy or solder only for mechanical board connection. The

design utilizes inductive coupling between the antenna and the strap, therefore no electrical connection is necessary.

Further, the mounting accuracy of the MAGICSTRAP® is not as critical as other technologies. Placement of the MAGICSTRAP® can be offset by as much as 0.8mm (using the 3216 size component) and will not cause significant performance degradation. Due to its unique design and attachment method, MAGICSTRAP® can withstand a 2kV ESD pulse.

Broadband Performance

MAGICSTRAP® is the first RFID PCB tag that offers full band impedance matching. This allows a single MAGICSTRAP® to operate from 850MHz to 960MHz frequency covering all the global UHF bands.

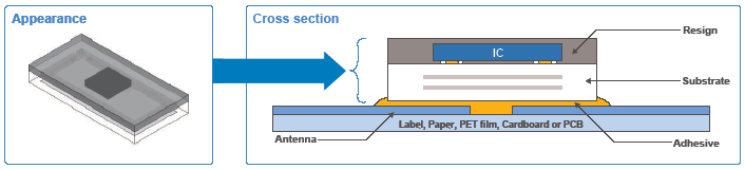

Figure 2 Cross-section of Murata MAGICSTRAP®

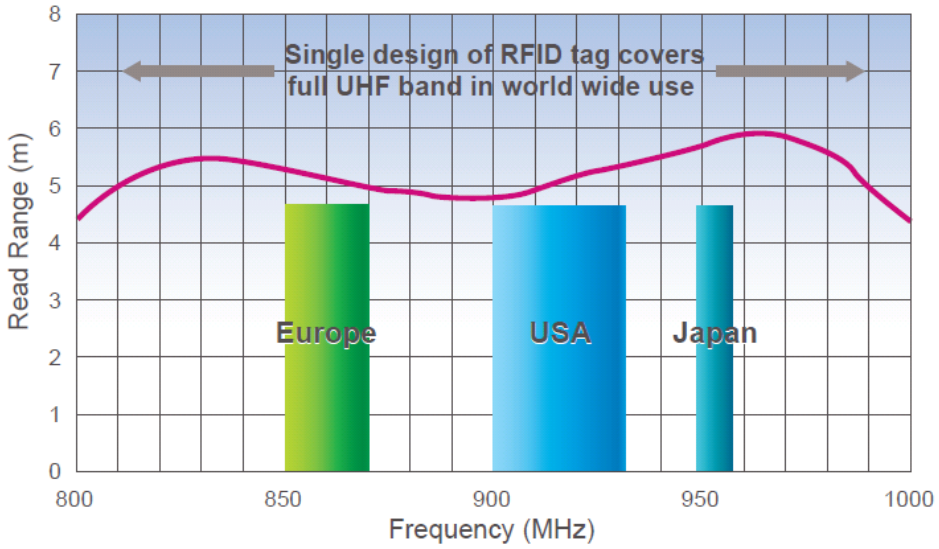

Figure 3 Broadband Performance

Common Antenna Interface

To resolve impedance matching issues, Murata's MAGICSTRAP® optimizes both the IC and antenna design impedance characteristics and provides a uniformed interface with the PCB board. This allows the designer to focus on optimizing the antenna's performance and not have to worry about impedance matching issues.

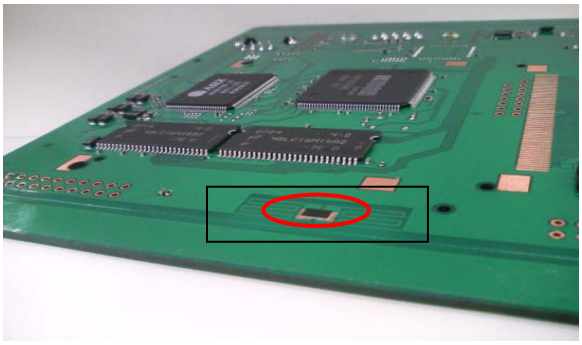

Figure 4 MAGICSTRAP® on Printed Circuit Board

Readability from the Finished Product

Readability of the finished product is one of the optimal goals of a PCB mounted RFID Tag. Murata has developed a reference of antenna design rules, sizes and shapes of commonly used PCB's and its applications. This not only minimizes design time but will optimize read distance. In most cases, a well designed antenna utilizing MAGICSTRAP® will be readable from the finished product when the PCB is not completely shielded with a metallic material and will still pass FCC certificate testing.

Conclusion

UHF RFID technologies have shown their advantage over barcodes in production tracking, asset management, anti-counterfeiting, service tracking and identifying production bottlenecks. Many OEMs and big contract manufacturers who struggle with global production and inventory controls have seen tremendous benefits of adopting RFID. Murata's MAGICSTRAP® addresses those concerns by confronting the challenges that were seen in earlier trials.

Features of Murata's RFID MAGICSTRAP® Include:

- Broadband performance
- Global acceptance
- IC transparent design
- Convenient package size

- Flexible mounting process options
- Readability from finished product
- Very high ESD tolerance
- Very high temperature tolerance
- Very high stability and reliability
- Cost effective